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ABSTRACT

Emphasizing higher order thinking skills is of primary concern within mathematics. Learning environments emphasizing the learner's understanding of the subject matter are constantly under review, with one learner-centered emphasis upon instruction leading the way: WebQuests. The design and development of WebQuests for the mathematical classroom environment offers the integration of mathematical subject matter, higher order thinking skills and a learner-centered emphasis of instruction. This paper discusses Bloom's Taxonomy which can create an appropriate format through which to view the developing levels of higher order thinking skills (HOTS); describes HOTS (by Thomas, Thorne and Small) which can be described as a composition of content thinking, critical thinking, and creating thinking, and each feature of which offers an emphasis towards a separate level featured within Bloom's Taxonomy; reviews eight aspects associated with HOTS; describes learning activities for the World Wide Web; and defines WebQuests, including essential aspects that must be incorporated in the design and development of successful WebQuests for use within a mathematical learning environment. Includes two tables and one figure. (Contains 7 references.) (Author/AEF)

Title: Focusing Upon Higher Order Thinking Skills: WebQuests and the Learner-Centered Mathematical Learning Environment

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Abstract

Emphasizing higher order thinking skills is of primary concern within mathematics. Learning environments emphasizing the learner's understanding of the subject matter are constantly under review, with one learner-centered emphasis upon instruction leading the way: WebQuests. The design and development of WebQuests for the mathematical classroom environment offers the integration of mathematical subject matter, higher order thinking skills and a learner-centered emphasis of instruction.

Introduction

The traditional attitude towards mathematics as a subject matter is one of drill-and-practice within a formulaic environment, with emphasis placed upon the learner's "correct" or "incorrect" response. As educational and sociological attitudes and expectations shift, the learning environment also changes; a more constructivist learner-centered emphasis is becoming more important, as working within a group dynamic and the ability of the learner to construct appropriate meanings is emphasized as imperative at the dawn of the Information Age. Mathematical learning environments emphasize the importance of higher order thinking skills within the learning environment. After all, "Effective teachers intuitively know that student attitudes and academic achievement are improved when learning experiences revolve around the interests, talents, and needs of students" (Texas Metronet Incorporated, 2001, paragraph 1). With the rise of the Internet

and the continual expansion of informational World Wide Web sites available within a learning environment, the incorporation of the Web within the mathematical learning environment offers significant strengths.

One aspect that offers the integration of mathematical subject matter, higher order thinking skills, and a learner-centered emphasis of instruction is the design and development of WebQuests for the mathematical classroom environment. A learner-centered, constructivist focus towards the instructor-controlled integration of the Web into a mathematics subject matter is the WebQuest.

Bloom's Taxonomy of the Cognitive Domain

As learners begin to obtain subject-specific knowledge, an emphasis must be placed upon the developing conceptual framework of understanding that is created. Bloom's Taxonomy creates an appropriate format through which to view the developing levels of higher order thinking skills as the learner moves beyond basic knowledge levels of information towards a level at which the learner is comfortable analyzing the information and then, finally, synthesizing and evaluating the information that has been appropriately and successfully incorporated within the learner's conceptual framework of understanding.

Following is a brief explanation of the distinct levels of Bloom's Taxonomy, with a short definition and sample learning objective verbs made available for review. Further, examples of behavior are presented to emphasize the specific levels of understanding.

LEVEL	*DEFINITION*	*SAMPLE*	*SAMPLE*

		VERBS	*BEHAVIORS*
KNOWLEDGE	Student recalls or recognizes information, ideas, and principles in the approximate form in which they were learned.	Write List Label Name State Define	The student will define the 6 levels of Bloom's taxonomy of the cognitive domain.
COMPREHENSION	Student translates, comprehends, or interprets information based on prior learning.	Explain Summarize Paraphrase Describe Illustrate	The student will explain the purpose of Bloom's taxonomy of the cognitive domain.
APPLICATION	Student selects, transfers, and uses data and principles to complete a problem or task with a minimum of direction.	Use Compute Solve Demonstrate Apply Construct	The student will write an instructional objective for each level of Bloom's taxonomy.
ANALYSIS	Student distinguishes, classifies, and relates the assumptions, hypotheses, evidence, or structure of a statement or question.	Analyze Categorize Compare Contrast Separate	The student will compare and contrast the cognitive and affective domains.
SYNTHESIS	Student originates,	Create	The student will

	integrates, and combines ideas into a product, plan or proposal that is new to him or her.	Design Hypothesize Invent Develop	design a classification scheme for writing educational objectives that combines the cognitive, affective, and psychomotor domains.
EVALUATION	Student appraises, assesses, or critiques on a basis of specific standards and criteria.	Judge Recommend Critique Justify	The student will judge the effective-ness of writing objectives using Bloom's taxonomy.

(Huitt, 2000, paragraph 2)

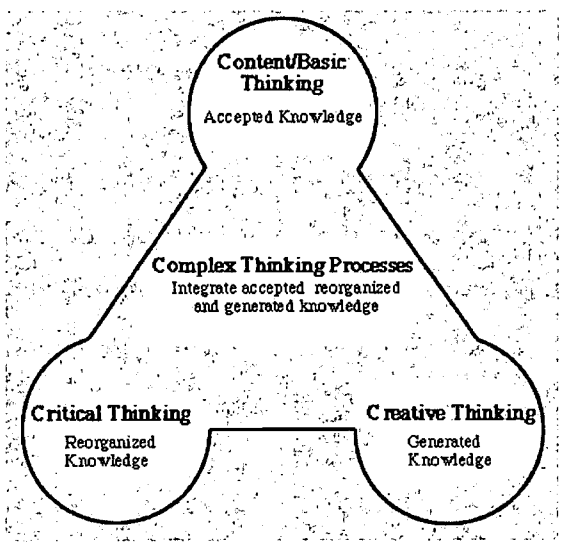
The focus of the learning environment is to aid the learner in reaching the synthesis and evaluation stages of Bloom's Taxonomy. The higher order thinking skills that the learner must reach are areas of further interest and discussion.

Higher Order Thinking Skills

The focus upon Bloom's Taxonomy may be further examined through the opportunities provided by higher order thinking skills. A brief description and explanation of higher order thinking skills by Thomas, Thorne and Small (2001) emphasize the overarching elements of importance:

> Higher Order Thinking, or HOT for short, takes thinking to higher levels than just restating the facts. HOT requires that we do something with the facts. We must understand them, connect them to each other, categorize them, manipulate them, put them together in new or novel ways, and apply them as we seek new solutions to new problems. (Thomas, Thorne & Small, 2001, paragraph 7)

As such, higher order thinking skills (HOTS) can be described as a composition of three categories: content thinking; critical thinking; and, creative thinking. Each feature of HOTS offers an emphasis towards a separate level featured within Bloom's Taxonomy. Each of the three HOTS categories of emphasis work together towards the suitable and flourishing successful continual development of the learner's conceptual framework of understanding, as displayed in the following graphic:



(Caldwell, Dake, Safly & Ulch, 1999, paragraph 1)

The more advanced, complicated stages of thinking processes related with HOTS closely corresponds and resembles the synthesis and evaluation levels instituted within Bloom's Taxonomy. As the generative relationships of higher order thinking are emphasized within all levels of the professional academic environment, subject areas must each highlight the creative and innovative elements that will work towards the enhancement of the learner's thought patterns' creation and reconceptualization. To state this more simplistically, the learner must refocus the theoretical understanding of the subject matter towards a real-world environment that offers numerous perspectives towards understanding. As a short review, eight aspects associated with HOTS are presented:

- No one thinks perfectly or poorly all the time.
- Memorizing something is not the same as thinking about it.
- You can memorize something without understanding it.
- Thinking is done in both words and pictures.
- There are three main types of intelligence and thinking: analytical, creative and practical.
- All three intelligences and ways of thinking are useful in our everyday lives.
- You can improve your thinking skills by understanding the processes involved in thinking.

- Metacognition–thinking about thinking–is part of higher order thinking. (Thomas, Thorne & Small, 2001, paragraph 6)

Therefore, the emphasis upon Bloom's Taxonomy and higher order thinking skills within the learning environment is an appropriate formula towards the learner's success within a classroom environment.

Correlated with the mathematics subject area of emphasis, the imperative elements associated with designing and developing appropriate instructional scope and sequence for the course must be carefully reviewed. With the introduction of the World Wide Web (Web) into the learning environment, an emphasis upon Bloom's Taxonomy's synthesis and evaluation levels are appropriate, while also maintaining and focusing efforts upon higher order thinking skills.

Learning Activities for the World Wide Web

The World Wide Web (Web) offers the availability of enormous amounts of information, available at the touch of a mouse or a mere keystroke. This information is free and available to anyone in the world, not merely to a small, distinct group of persons. As such, the amount of information available may cause high levels of despair and confusion for both the professional educator and the learner. Due to this concern, thoughtful consideration must occur so as to design appropriate and quality learning activities that integrate the Web's strengths and assets. The professional educator has the mission and responsibility to design and develop appropriate and successful learning

environments for their learners, whether the product is focused upon the instructor-centered or the learner-centered educational environment.

Over the previous fifteen-year period, a developing awareness of the constructivist theories and applications within learning environments has taken shape. Learning environments focused upon the inquiry-oriented, problem solving, learner-centered have developed. As the focus upon the learner's opportunities and needs has matured, the professional educator has changed roles from instructor to facilitator, also annoying referred to as a shift from the "sage on the stage" to the "guide on the side". As group work has also made a debut and developed a significant following within the educational realm, these characteristics were melded into an innovative outcome presented by Dodge (1998, 2001a, 2001b) as a WebQuest. A WebQuest is:

- Inquiry-oriented;
- Internet resource-heavy;
- Optional videoconference support (Dodge, 2001, paragraph 1);
- Group work-centered; and,
- Higher Order Thinking Skills-focused.

Each of these characteristics adds important components to the learner-centered environment in which a conceptual framework of understanding is facilitated by the facilitator.

WebQuest

WebQuests emphasize higher order thinking skills as well as the progressively higher levels of Bloom's Taxonomy. Following is a quick explanation of higher order thinking skills, as presented by Dodge (1998).

Definition	**Parts**	**Underpinnings**
• Inquiry-oriented • Based on a doable, engaging task • Uses pre-defined resources from the Web (and others) • Can be short or long term	• Introduction • Task • Process • Resources • Evaluation • Conclusion	• Constructivism • Cooperative Learning • Scaffolding • Fading
Tasks for Bloom's Penthouse	**Scaffolding: How?**	**Examples**
• Synthesize conflicting opinions • Put multiple sources of data together to discover the non-obvious • Create something new within the contraints of a problem definition	Provide... • resource links • a compelling problem or task • templates for student products • guidance on cognitive and social skills	• Aztec Adventure • The Titanic • Treking the Sante Fe Trail • To Kill a Mockingbird • Conflict Yellowstone Wolves

• Define a stance and defend it	and social skills	

(Dodge, 1998, paragraph1)

As the information related to higher order thinking skills is presented in a simplistic format for review, it is obvious that problem-solving opportunities are imperative elements within the learning environment.

A Web-based product design that emphasizes such an environment is the WebQuest. A WebQuest may be developed for numerous subject areas; however, mathematics offers a special emphasis towards the learning environment's integration of the World Wide Web due to the real-world, problem-solving nature of the mathematical learning environment situation. This opportunity offers the learner a cooperative environment through which to scaffold the developing information and to emphasize the use of mathematics in the solution to the problem that is presented within the WebQuest.

Emphasis is focused upon the design and development of mathematically appropriate subject matter so as to create a simulation-style environment that develops a dynamic, innovative problem-solving community in which the learners can thrive. Dodge's definition of "A WebQuest is an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the Internet, optionally supplemented with videoconferencing" (Dodge, 2001a) simplistically orients the focus of the WebQuest within the learning environment. Designing and developing an appropriate and successful WebQuest for use within a mathematical learning environment must incorporate the following essential aspects:

- An Engaging Opening
- The Question / Task
- Background for Everyone
- Roles / Expertise
- Use of the Web
- Transformative Thinking
- Real World Feedback
- Conclusion (Dodge, 2001b, paragraph 1)

Numerous interesting, inquiry-oriented and subject-specific WebQuests can be produced and successfully integrated into a mathematical learning environment. Emphasis focused upon the real-world application of mathematical theories and concepts offers an engaging view of the world for the learners. Following are sample WebQuests available online:

- The Titanic at http://asterix.ednet.lsu.edu/~edtech/webquest/titanic.html
- Best Weather City at http://www.wfu.edu/~mccoy/NCTM99/weather.html
- National Park Vacation at http://www.wfu.edu/~mccoy/NCTM99/vacation.html
- Most Thrilling Roller Coaster at http://www.wfu.edu/~mccoy/NCTM99/coasters.html
- World Shopping Spree at http://www.wfu.edu/~mccoy/NCTM99/shopping.html
- Baseball Prediction at http://www.wfu.edu/~mccoy/NCTM99/baseball.html

As well, sharing the successful WebQuests developed by professional educators offers innumerable opportunities and support for fellow professionals around the world; therefore, uploading the WebQuests to an appropriate Web server offers the ability to

share the WebQuests with others and to integrate the WebQuests so as to ensure the active learning occurrences of other learners around the world.

Integration of WebQuests into the Mathematics Curriculum

The integration of WebQuests into the mathematics curriculum is an art that only professional educators may claim. WebQuests that should be integrated into the mathematics learning environment should offer the following elements:

- Problem-based applications
- Real-world data sets
- Real world applications
- Learner-centered focus
- Subject matter expertise
- Emphasizes the learner's complex thinking processes
- Emphasizes the learner's metacognitive processes

Each of these elements adds to the overall impact and higher order thinking skills of the learner.

Conclusion

The integration of Bloom's Taxonomy and higher order thinking skills into the mathematical learning environment occurs naturally, due to the characteristics of the subject matter. However, the introduction and integration of WebQuests offers a learner-centered focus to problem-based, real-world applications that can be applied within a

mathematical learning environment. The vast information available on the World Wide Web offers the opportunity to further define and develop a learner's subject matter expertise using real-world information. Combining two such powerful areas, mathematics and the World Wide Web, aids the movement towards the emphasis on and realization of an innovative learning environment that reinforces a learner's complex metacognitive processes and offers opportunities towards scaffolding complex thinking processes towards cognitive frameworks of understanding.

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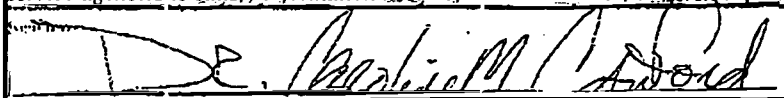

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